Survey of Northern Abalone, *Haliotis kamtschatkana,* Populations Along North-West Vancouver Island, British Columbia, May 2003

M. Atkins and J. Lessard

Fisheries and Oceans Canada
Science Branch, Pacific Region
Pacific Biological Station
Nanaimo, British Columbia
V9T 6N7

2004

Canadian Manuscript Report of Fisheries and Aquatic Sciences 2690

Fisheries and Oceans Canada | Pêches et Océans Canada

Canada

Canadian Manuscript Report of Fisheries and Aquatic Sciences

Manuscript reports contain scientific and technical information that contributes to existing knowledge but which deals with national or regional problems. Distribution is restricted to institutions or individuals located in particular regions of Canada. However, no restriction is placed on subject matter, and the series reflects the broad interests and policies of the Department of Fisheries and Oceans, namely, fisheries and aquatic sciences.

Manuscript reports may be cited as full publications. The correct citation appears above the abstract of each report. Each report is abstracted in *Aquatic Sciences and Fisheries Abstracts* and indexed in the Department's annual index to scientific and technical publications.

Numbers 1-900 in this series were issued as Manuscript Reports (Biological Series) of the Biological Board of Canada, and subsequent to 1937 when the name of the Board was changed by Act of Parliament, as Manuscript Reports (Biological Series) of the Fisheries Research Board of Canada. Numbers 1426 - 1550 were issued as Department of Fisheries and the Environment, Fisheries and Marine Service Manuscript Reports. The current series name was changed with report number 1551.

Manuscript reports are produced regionally but are numbered nationally. Requests for individual reports will be filled by the issuing establishment listed on the front cover and title page. Out-of-stock reports will be supplied for a fee by commercial agents.

Rapport manuscrit canadien des sciences halieutiques et aquatiques

Les rapports manuscrits contiennent des renseignements scientifiques et techniques ques qui constituent une contribution aux connaissances actuelles, mais qui traitent de problèmes nationaux ou régionaux. La distribution en est limitée aux organismes et aux personnes de régions particulières du Canada. Il n'y a aucune restriction quant au sujet; de fait, la série reflète la vaste gamme des intérêts et des politiques du ministère des Pêches et des Océans, c'est-à-dire les sciences halieutiques et aquatiques.

Les rapports manuscrits peuvent être cités comme des publications complètes. Le titre exact paraît au-dessus du résumé de chaque rapport. Les rapports manuscrits sont résumés dans la revue *Résumés des sciences aquatiques et halieutiques*, et ils sont classés dans l'index annual des publications scientifiques et techniques du Ministère.

Les numéros 1 à 900 de cette série ont été publiés à titre de manuscrits (série biologique) de l'Office de biologie du Canada, et après le changement de la désignation de cet organisme par décret du Parlement, en 1937, ont été classés comme manuscrits (série biologique) de l'Office des recherches sur les pêcheries du Canada. Les numéros 901 à 1425 ont été publiés à titre de rapports manuscrits de l'Office des recherches sur les pêcheries du Canada. Les numéros 1426 à 1550 sont parus à titre de rapports manuscrits du Service des pêches et de la mer, ministère des Pêches et de l'Environnement. Le nom actuel de la série a été établi lors de la parution du numéro 1551.

Les rapports manuscrits sont produits a l'échelon régional, mais numérotés à l'échelon national. Les demandes de rapports seront satisfaites par l'établissement auteur dont le nom figure sur la couverture et la page du titre. Les rapports épuisés seront fournis contre rétribution par des agents commerciaux.

104-07281/

Canadian Manuscript Report of

Fisheries and Aquatic Sciences 2690

2004

SURVEY OF NORTHERN ABALONE, *Haliotis kamtschatkana*, POPULATIONS ALONG NORTH-WEST VANCOUVER ISLAND, BRITISH COLUMBIA, MAY 2003

by

M. Atkins and J. Lessard

Fisheries and Oceans Canada

Science Branch, Pacific Region

Pacific Biological Station

Nanaimo, British Columbia

V9T 6N7

© Her Majesty the Queen in Right of Canada, 2004.

Cat. No. Fs 97-4 /2690E ISSN 0706-6473

Correct citation for this publication:

Atkins, M. and Lessard, J. 2004. Survey of northern abalone, *Haliotis kamtschatkana*, populations along north-west Vancouver Island, British Columbia, May 2003. Can. Manuscr. Rep. Fish. Aquat. Sci. 2690: 12 p.

ABSTRACT

Atkins, M. and Lessard, J. 2004. Survey of northern abalone, *Haliotis kamtschatkana*, populations along north-west Vancouver Island, British Columbia, May 2003. Can. Manuscr. Rep. Fish. Aquat. Sci. 2690: 12 p.

Northern, or Pinto, abalone, *Haliotis kamtschatkana*, have been protected by harvest closures since 1990 due to low population levels. Index site surveys have been preformed by Fisheries & Oceans Canada since 1978 to monitor the recovery of the abalone populations in British Columbia. This survey was the first on the north-west coast of Vancouver Island, and will be used as reference for future surveys in this area. Northern abalone were found at eight (25%) of the 32 sites surveyed. The density in Quatsino Sound was 0.21 ± 0.04 abalone / m^2, which is close to the densities surveyed in 2002 in the Queen Charlotte Islands (0.34 ± 0.06 abalone/m^2), and in 2001 on the central coast (0.27 ± 0.04 abalone/m^2). In total, nearly 60% of the individuals sampled were immature (<70 mm shell length); the large proportion of immature individuals shows a potential for a future recruitment pulse, however, population increases will be small until such time.

RÉSUMÉ

Atkins, M. and Lessard, J. 2004. Survey of northern abalone, *Haliotis kamtschatkana*, populations along north-west Vancouver Island, British Columbia, May 2003. Can. Manuscr. Rep. Fish. Aquat. Sci. 2690: 12 p.

La pêche de l'ormeaux nordique, *Haliotis kamtschatkana*, de la Colombie-Britannique est complètement fermée depuis 1990 afin d'assurer la conservation de l'espèce. Des relevés à des sites indicateurs ont été effectués par Pêches et Océans Canada depuis 1978 pour surveiller le rétablissement des populations d'ormeaux. Le relevé décrit ici est le premier effectué sur la partie nord-ouest de la côte de l'Île de Vancouver et sera utilisé comme référence pour de futurs relevés à cet endroit. Des ormeaux étaient présents à 8 (25%) des 32 sites échantillonnés. La densité dans le détroit de Quatsino était de 0.21 ± 0.04 ormeau/m^2. Cet estimé est similaire aux résultats des relevés dans les Îles de la Reine Charlotte en 2002 (0.34 ± 0.06 ormeau/m^2) et de la côte centrale de la C.-B. en 2001 (0.27 ± 0.04 ormeau/m^2). En incluant tous les résultats de ce relevé, presque 60% des individus étaient immatures (<70 mm de longueur); la grande proportion de ces animaux démontrent un potentiel pour un taux élevé de recrutement dans le futur. Cependant, la croissance de population sera faible d'ici-là.

INTRODUCTION

The northern, or pinto, abalone, *Haliotis kamtschatkana*, generally occurs in patchy distributions along exposed or semi-exposed coastlines from Yakutat, Alaska to Baja California (Sloan and Breen 1988; O'Clair and O'Clair 1998). In British Columbia (BC), abalone were a traditional food source for First Nations, and were harvested by recreational and commercial divers until 1990. Due to low stock numbers the Department of Fisheries & Oceans Canada placed a complete ban on abalone harvesting in December, 1990. Surveys of index sites along the central coast of BC and the Queen Charlottes showed evidence of a 75-80% decline in abalone abundance in the period of 1978-1990 (Thomas *et al.* 1990; Farlinger *et al.* 1991; Campbell 2000). Despite harvest closures, their numbers remain low and in 1999 northern abalone was listed as 'threatened' by the Committee on the Status of Endangered Wildlife in Canada (Campbell 2000; Jamieson 2001).

The objective of this survey was to determine the population density and size frequency of abalone populations on the north-west coast of Vancouver Island. To date no systematic surveys to determine abalone abundance have been completed on the north-west coast of Vancouver Island, primarily due to low historic fishery catches (9 t between 1977 and 1990) (Harbo 1997). Past surveys focused on the central coast and the Queen Charlotte Islands because of their higher reported fisheries catches; 497 t and 752 t respectively between 1977 and 1990. The results of this survey may be used in conjunction with other index site survey results in BC to establish baseline abalone abundance data and evaluate the effectiveness of conservation efforts along the coast.

METHODS

The Canadian Coast Guard research vessel 'CCGS Vector' acted as the live-aboard platform from which daily operations commenced. Two smaller support vessels transported two dive teams to and from the sites for four days in May, 2003. Both boats were equipped with GPS to find the precise location of each pre-determined site.

A total of 50 sites were randomly chosen from Pacific Fishery Management Areas 27 and 127 (Fig. 1); of these, 18 sites were removed due to unfavourable abalone habitat conditions such as heavy wave exposure, or sand/gravel substrate. The remaining 32 sites were sampled using the 'Breen' survey method (Breen and Adkins 1979).

Once each site was located, divers placed a 1 m^2 quadrat at the top of the abalone habitat zone and then sampled 16 quadrats within a 7 m by 16 m area (4 rows of 4 quadrats). Vegetation was cleared from the substrate and all visible "exposed" abalone were counted and measured. Divers also recorded the dominant algal species, substrate type, depth and urchin counts. During past surveys divers turned boulders and rocks in search of hidden or cryptic abalone, but during this survey, in an effort to conserve time and increase sample size, only exposed abalone were recorded. Sampling only

exposed abalone is an efficient sampling strategy, since the majority of mature abalone (*i.e.*, ≥70 mm shell length (SL)) are exposed (Campbell 1996; Cripps and Campbell 1998). If no abalone were seen by the eighth quadrat, the dive was aborted and the site count was scored as zero. Each site was considered to be a single sample for the density estimates, with the 16 quadrats per site as secondary sampling units.

All recorded depths were corrected for tide heights post survey. Abalone densities were estimated as the number/m^2 for total (all sizes), as well as for several size categories: immature (<70 mm); mature (≥70 mm); pre-recruit (92-99 mm); new recruit (100-106 mm) and legal (≥100 mm SL). The smallest size at which 100% of abalone are mature was found to be approximately 70 mm SL (Campbell *et al.* 1992). Growth curves provided by Quayle (1971) and Breen (1986) were used to estimate pre-recruit and recruit sizes for northern abalone. Densities of immature abalone should be treated with caution due to the increased difficulty of detecting smaller individuals.

Tissue samples were taken from abalone collected at a single site (site 46) for future DNA analysis. From each abalone, a small clip of epipodial tissue was taken and preserved with 70%, or higher, ethanol. The results of the DNA analysis will be presented elsewhere. The size frequency results are presented here, but are not included in the density estimates as no area measurement, *i.e.* quadrat, was used while collecting these animals.

RESULTS

A total of 32 sites were sampled along the north-west coast of Vancouver Island in May of 2003. An average of 20 minutes (range 9-44 min) was spent sampling each site (Table 1). The survey results were separated into 3 areas of similar habitat: Quatsino Sound (n=13), Brooks Bay (n=5), and all other 'exposed' areas (n=14). Exposed areas were characterized by bedrock substrate and heavy wave exposure. Brooks Bay sites were slightly more protected, characterized by bedrock substrate, with boulders and cobble substrate also present (Table 2). Sites surveyed in Quatsino Sound were more sheltered, had more algae cover, and boulder was the dominant substrate. Abalone were found in eight (25%) sites; seven of which were located in Quatsino Sound, and one in Brooks Bay. Abalone were only observed in sites containing bedrock with crevices, and/or boulders, which, in either case, could provide refuge from predators (Table 2). Sea urchins were also found at all sites with abalone (Table 1).

The total number of abalone sampled was 47; of these 28 (59.6%) were immature (Table 3). The mean shell length was 59.1mm; the smallest abalone measured was 17 mm and the largest was 101 mm (Fig. 2). Only two (4.3%) were above the historic legal harvest size of 100 mm SL.

The majority of abalone sampled were found in four meters or less of water (at chart datum) (Fig. 3). The total mean density of abalone in the area surveyed was

0.092/m^2; Quatsino Sound had a density of 0.212/m^2, and Brooks Bay a density of 0.038/m^2. No abalone were found along the outermost exposed coastline. Urchins were also counted. All species of urchin were grouped, but counts generally reflected red sea urchin (*Strongylocentrotus franciscanus*) abundance as other species (*S. droebachiensis* and *S. purpuratus*) were rare. The overall urchin density was 0.795/m^2, with 0.462/m^2 in Quatsino Sound and 1.375/m^2 in Brooks Bay.

A single site was chosen from which 84 additional abalone were collected and sampled for DNA analysis. A size frequency graph was constructed (Fig. 4); the mean shell length was 67.2 mm (SE=1.4 mm) with a minimum shell length of 35 mm and a maximum of 100 mm. The size frequency may be biased due to divers preferentially selecting larger individuals.

DISCUSSION

This was the first abalone survey on the northern region of Vancouver Island. The overall observed population density (0.09 ± 0.04 abalone/m^2) in 2003 was relatively low. The majority of sites where abalone were present were located in Quatsino Sound, where the density estimate (0.21 ± 0.08 abalone/m^2) indicates similar population densities to those observed in the 2002 Queen Charlotte Island (0.34 ± 0.06 abalone/m^2) (unpublished) and 2001 Central Coast (0.27 ± 0.04 abalone/m^2) (unpublished) index site surveys.

Approximately 60% of abalone surveyed were immature (Table 3) suggesting a slow population increase until such time that the immature individuals reach sexual maturity, at which time a recruitment pulse would be expected. Although larger individuals were targeted for the DNA sample, all but one animal were smaller than 100 mm SL (Fig. 4). The small sizes could indicate stunted growth due to high exposure to wave action and/or currents and low food supply (Sloan and Breen 1988). Population structure may also be dictated by the presence of sea otters in the area. Larger abalone tend to be less cryptic (Campbell 1996) and sea otters may be removing these larger, more exposed abalone from the area.

Sea otters were first observed in 1989 in Quatsino Sound and in 1991 in the area of Brooks Bay (Watson *et al.* 1997). The population is now well established in Brooks Bay and during the last sea otter survey in 2003, rafts were observed around Drake Island, well within Quatsino Sound (Linda Nichol, Pacific Biological Station, Nanaimo, BC, V9T 6N7; pers. comm.).

Watson (1993, 2000) has studied the effect of sea otters (*Enhydra lutris*) on nearshore ecosystems continuously between 1987 and 1998. Abalone densities ranged from 0.2 ± 0.2 to 19.4 ± 5.0 abalone/20m^2 (0.01 to 0.97 abalone/m^2) in areas with no otters or prior to their arrival, to densities <1 abalone/20m^2 where otters were present. Abalone found in areas occupied by sea otters were restricted to crevices inaccessible to foraging otters (Watson 1993). Even surveying only exposed abalone, in 2003 abalone were present in areas where otters are established at higher abalone

densities than that estimated by Watson (1993) in areas with sea otters. This may be the result of the relatively low densities which make abalone a scarce food resource for sea otters and are therefore not selected as sea otters often exploit seasonally abundant food resources (Watson *et al.* 1997). Since abalone densities prior to the presence of sea otters within this area are unknown, the effect of sea otters on the abalone population is only speculative.

At all the 2003 survey sites where abalone were present, urchins, mainly red sea urchins, were found as well. This was expected as red sea urchin and abalone share similar habitat characteristics (Tomascik and Holmes 2003). Urchin density from all sites surveyed in 2003 (0.417/m^2) was low compared to urchin stock assessment densities throughout the coast (densities ranged from 0.1 to 12.6 urchins/m^2; Table 4 in Campbell *et al.* 2000). The low urchin density observed in this study may be the result of sea otter predation. The arrival of sea otters at 3 out of 4 permanently marked sites in the 1993 study by Watson described above was followed by a decline in sea urchins and an increase in algae. At the 4th site, Kyuquot Bay (PFMA 26, south of Brooks Peninsula), sporadic foraging resulted in a patchy mosaic of urchins and algae.

This study suggests that abalone populations are small or non-existent on the north-west coast of Vancouver Island, with the exception of Quatsino Sound and Brooks Bay. Much of the coastline here is completely exposed to the open Pacific, and the shallow subtidal may be too inhospitable for the abalone to survive outside of these protected areas. For future surveys, we recommend that sites be selected within Quatsino Sound and Brooks Bay areas alone. We suggest that all sites within these 2 areas be re-surveyed (with the exception of site 34, which was too protected and too steep with the surrounding areas made up of gravel beach), with additional sites surveyed in Brooks Bay.

ACKNOWLEDGEMENTS

Thanks to Doug Brouwer and Alan Campbell for survey design and logistics support. Thanks also to Dimitri Tzotzos, Pauline Ridings, and James Paterson for diving; the crew of the Vector for field assistance; and Linda Nichol and Leslie Barton for reviewing the manuscript.

REFERENCES

Breen, P. A. 1986. Management of the British Columbia fishery for northern abalone (*Haliotis kamtschatkana*). Can. Spec. Publ. Fish. Aquat. Sci. 92: 300-312.

Breen, P. A. and Adkins, B. E. 1979. A survey of abalone populations on the east coast of the Queen Charlotte Islands, August 1978. Fish. Mar. Serv. Manuscr. Rep. 1490: 125 p.

Campbell, A. 1996. An evaluation of abalone surveys off southeast Queen Charlotte Island. Can. Tech. Rep. Fish. Aquat. Sci. 2089: 111-131 p.

Campbell, A. 2000. Review of northern abalone, *Haliotis kamtschatkana*, stock status in British Columbia. Can. Spec. Public. Fish. Aquat. Sci. 130: 41-50 p.

Campbell, A., Bureau, D., and Brouwer, D. 2000. Quota estimates for the 1998 red sea urchin fishery in British Columbia. Can. Manuscr Rep. Fish. Aquat. Sci. 2516: 31 p.

Campbell, A., Manley, I., and Carolsfeld, W. 1992. Size at maturity and fecundity of the abalone, *Haliotis kamtschatkana*, in northern British Columbia. Can. Manuscr. Rep. Fish. Aquat. Sci. 2169: 47-65.

Cripps, K. and Campbell, A. 1998. Survey of abalone populations at Dallain Point and Higgins Pass, central coast of British Columbia, 1995-96. Can. Manuscr. Rep. Fish. Aquat. Sci. 2445: 31 p.

Farlinger, S.,.Thomas, G. A, Winther, I., and Carolsfeld, W. 1991. Abalone resurvey in the Estevan Group and Aristazabal Island, June 1989. Can. Manuscr. Rep. Fish. Aquat. Sci. 2104: 39 p.

Harbo, R. 1997. Abalone Dive Fishery (closed). Can. Manuscr. Rep. Fish. Aquat. Sci. 2369: 86-92

Jamieson, G. S. 2001. Review of status of northern abalone, *Haliotis kamstchatkana*, in Canada. Canadian Field-Naturalist 115: 555-563

O'Clair, R. M. and O'Clair, C. E. 1998. Southeast Alaska's Rocky Shores - Animals. Plant Press, Auke Bay, Alaska. 561 p.

Quayle, D. B. 1971. Growth, morphometry and breeding in the British Columbia abalone (*Haliotis kamtschatkana* Jonas). Fish. Res. Bd Can. Tech. Rep. Ser. 279: 84 p.

Sloan, N. A. and Breen, P. A. 1988. Northern abalone, *Haliotis kamchatkana* in British Columbia: fisheries and synopsis of life history information. Can. Spec. Public. Fish. Aquat. Sci. 103: 46 p.

Thomas, G., Farlinger, S., and Carolsfeld, W. 1990. Abalone resurvey in the southeast Queen Charlotte Islands in 1990. Can. Manuscr. Rep. Fish. Aquat. Sci. 2099: 66-82.

Tomascik, T. and Holmes, H. 2003. Distribution and abundance of *Haliotis kamtschatkana* in relation to habitat, competitors and predators in the Broken Group Islands, Pacific Rim National Park Reserve of Canada. J. Shellfish Res. 22: 831-838.

Watson, J. C. 2000. The effects of sea otters (*Enhydra lutris*) on abalone (*Haliotis* spp.) populations. *In* Workshop on Rebuilding Abalone Stocks in British Columbia. *Edited by* A. Campbell. Can. Spec. Publ. Fish. Aquat. Sci. 130. pp. 123-132.

Watson, J. C. 1993. The effects of sea otter (*Enhydra lutris*) foraging on shallow rocky communities off northwestern Vancouver Island, British Columbia. Dissertation, University of California, Santa Cruz, Cal. 169 p.

Watson, J. C., Ellis, G. M., Smith, T. G., and Ford, J. K. B. 1997. Updated status of the sea otter, *Enhydra lutris*, in Canada. Canadian Field-Naturalist 111: 277-286.

Table 1. Dive survey summary for abalone transects surveyed on the north-west coast of Vancouver Island, May 2003.

Site	Date	Time Start	Time Finish	Bottom Time	Depth (m) Min	Depth (m) Max	# of Quadrats	# of Abalone	Density (#/m^2)	# of Urchins	Density (#/m^2)
Quatsino Sound											
1	May-07	13:58	14:34	36	0	3	16	8	0.500	15	0.938
4	May-08	10:31	10:59	28	1	6	16	2	0.125	23	1.438
5	May-07	13:33	13:47	14	1	2	8	0	0.000	1	0.125
9	May-08	14:02	14:26	24	0	4	8	0	0.000	0	0.000
10	May-08	11:11	11:33	22	1	4	16	5	0.313	10	0.625
12	May-08	9:43	10:11	28	0	3	16	3	0.188	3	0.188
13	May-08	12:49	13:12	23	1	4	16	3	0.188	22	1.375
20	May-08	14:50	15:07	17	0	2	8	0	0.000	0	0.000
24	May-08	13:23	13:33	10	0	3	8	0	0.000	0	0.000
25	May-07	15:45	16:13	28	0	3	8	0	0.000	0	0.000
34	May-08	14:12	14:21	9	1	7	8	0	0.000	0	0.000
46	May-08	12:57	13:41	44	0	7	16	17	1.063	19	1.188
47	May-07	14:43	15:07	24	3	6	16	6	0.375	2	0.125
Total (n=13)								**44**	**0.212**	**95**	**0.462**
Brooks Bay											
11	May-09	12:26	12:37	11	-1	3	8	0	0.000	0	0.000
15	May-09	11:23	11:33	10	-1	1	8	0	0.000	0	0.000
19	May-09	11:43	11:53	10	2	5	8	0	0.000	0	0.000
26	May-09	10:49	11:19	30	0	6	16	3	0.188	1	0.063
50	May-09	11:47	12:04	17	0	2	8	0	0.000	1	0.125
Total (n=5)								**3**	**0.038**	**2**	**0.038**
Exposed Sites											
2	May-06	12:11	12:37	26	3	4	8	0	0.000	0	0.000
6	May-07	8:30	8:40	10	1	2	8	0	0.000	0	0.000
7	May-06	11:54	12:18	24	3	5	8	0	0.000	73	9.125
8	May-07	14:33	14:50	17	1	3	8	0	0.000	0	0.000
14	May-07	8:54	9:03	9	2	3	8	0	0.000	0	0.000
17	May-07	15:04	15:20	16	-1	0	8	0	0.000	0	0.000
28	May-06	11:23	11:39	16	3	4	8	0	0.000	81	10.125
31	May-06	11:24	11:38	14	2	6	8	0	0.000	0	0.000
33	May-07	15:44	15:57	13	0	1	8	0	0.000	0	0.000
36	May-07	12:15	12:40	25	2	4	8	0	0.000	0	0.000
38	May-07	11:16	11:38	22	0	2	8	0	0.000	0	0.000
43	May-07	9:42	10:05	23	2	3	8	0	0.000	0	0.000
45	May-06	14:04	14:28	24	0	2	8	0	0.000	0	0.000
48	May-07	9:17	9:35	18	1	3	8	0	0.000	0	0.000
Total (n=14)								**0**	**0.000**	**154**	**1.375**
All Sites											
Total (n=32)								**47**	**0.092**	**251**	**0.795**

Table 2. Site descriptions of all 32 sites sampled on the north-west coast of Vancouver Island, May 2003. The most common substrates are listed (1 = first, 2 = second, 3 = third) where substrate code 1 = smooth bedrock, 2 = bedrock with crevices, 3 = boulders, 4 = cobble, 5 = gravel, 6 = pea gravel, 7 = sand, 8 = shell. The algae are listed by growth characteristics for the most common (Sp 1) and second most common (Sp 2) with percentage cover (%) for each, where AG = *Agarum* sp, AC = articulated corallines, CO = *Costaria costata*, DE = *Desmarestia* sp, IR = *Iridaea* sp (*Maziella* sp), LA = *Laminaria* sp., LT = *Laminaria setchellii*, MA = *Macrocystis integrifolia*, NT = *Nereocystis luetkeana*, PH = *Phyllospadix* sp, PT = *Pterygophora californica*, RB = red branched, RF = red foliose, RH = red filamentous.

	Substrate			Slope	Canopy			Understory				Turf				Encrusting
Site	1	2	3	%	Sp1	%	Sp2	%	Sp1	%	Sp2	%	Sp1	%	Sp2	%
Quatsino Sound																
1	2	3		19	PT	50		0	LT	10		0	DE	10		0	70
4	3	4			MA	10		0	PT	40		0	DE	5		0	80
5	3	4	7	15	MA	50	PT	30		0		0		0		0	70
9	4	5	7	42	MA	30		0	AG	90		0		0		0	10
10	3	4	7		MA	10		0	PT	20		0	DE	10	AC	10	80
12	3	2			MA	30		0	PT	70	LT	70	AC	80	DE	80	60
13	3	4	7	19	MA	10		0	AG	90		0	AC	10		0	70
20	4	5	7	30	MA	100		0	AG	100		0	AC	10		0	10
24	3	4		34	MA	40		0	PT	40		0	PH	10	AC	10	60
25	2			30	PT	100		0	DE	5		0	IR	10	AC	10	60
34	2	3	7	76	MA	5		0	AG	50		0		0		0	70
46	1	3	4	42		0		0	PT	50		0		0		0	90
47	3	4	8	19	PT	50	MA	10					DE	20			90
Brooks Bay																
11	2	8		46	MA	5		0	AG	80		0	AC	10		0	20
15	2			27		0		0	PH	100	DE	100	AC	80		0	5
19	3	7		27		0		0	PH	100	DE	100	AC	80		0	60
26	2	7		36	MA	50		0	MA	50		0	AC	30		0	80
50	2			23	MA	60		0	PT	10	PH	10	AC	50		0	80
Exposed Sites																
2	2	3		19	NT	70		0	LT	100	DE	0	AC	30	RB	0	90
6	2	5		11		0		0	LT	10		0	PH	50	AC	50	60
7	2	3	7	34	NT	10		0	DE	10	RB	0	AC	10		0	90
8	4	3	57	27	MA	70		0		0		0	RF	30	AC	30	20
14	2			15		0		0	LT	20		0	AC	60	LT	20	70
17	1	7		15		0		0		0		0		0		0	0
28	2	3	8	15	PT	25	LA	25	LA	25	CO	25	AC	10		0	100
31	2	3		57	PT	1		0	PH	1		0	RH	80		0	100
33	1	3	4	4		0		0	LA	10		0	PH	80	AC	80	90
36	1	4		27		0		0	PH	30	PT	30	AC	10		0	80
38	1	5		27		0		0	LA	30	PT	30	PH	50		0	80
43	2	5		19		0		0	LA	100		0	RH	75	RF	75	75
45	3	4		14		0		0	PH	50	LT	20	AC	50		0	0
48	2			27	PT	90		0	LT	10	PL	20	DE	30	AC	40	60

Table 3. Mean shell lengths (mm SL) of exposed abalone of different size groups for all transect surveys on the north-west coast of Vancouver Island, May 2003.

Size Group	(mm SL)	N†	% of Total	Density‡	Shell Length‡
Immature	<70	28	59.57	0.055 (0.032)	41.9 (3.0)
Mature	≥70	19	40.43	0.037 (0.014)	81.8 (1.2)
Pre-Recruit	92-99	3	6.38	0.006 (0.003)	96.3 (1.5)
New Recruit	100-106	2	4.25	0.004 (0.004)	100.5 (0.5)
Legal	≥100	2	4.25	0.004 (0.004)	100.5 (0.5)
Total		47	100.00	0.092 (0.038)	59.1 (3.7)

† Number of Abalone ‡ Values in Brackets are standard errors

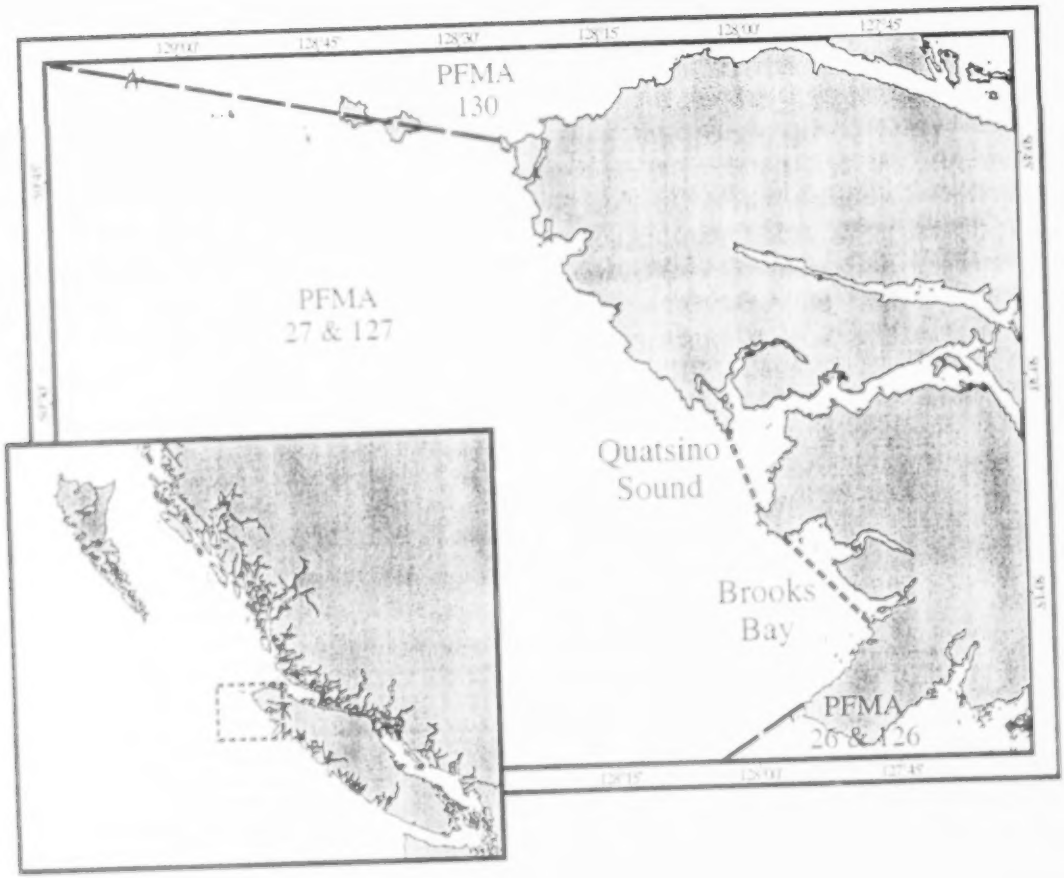

Figure 1. Map of abalone survey area, north-west coast of Vancouver Island.

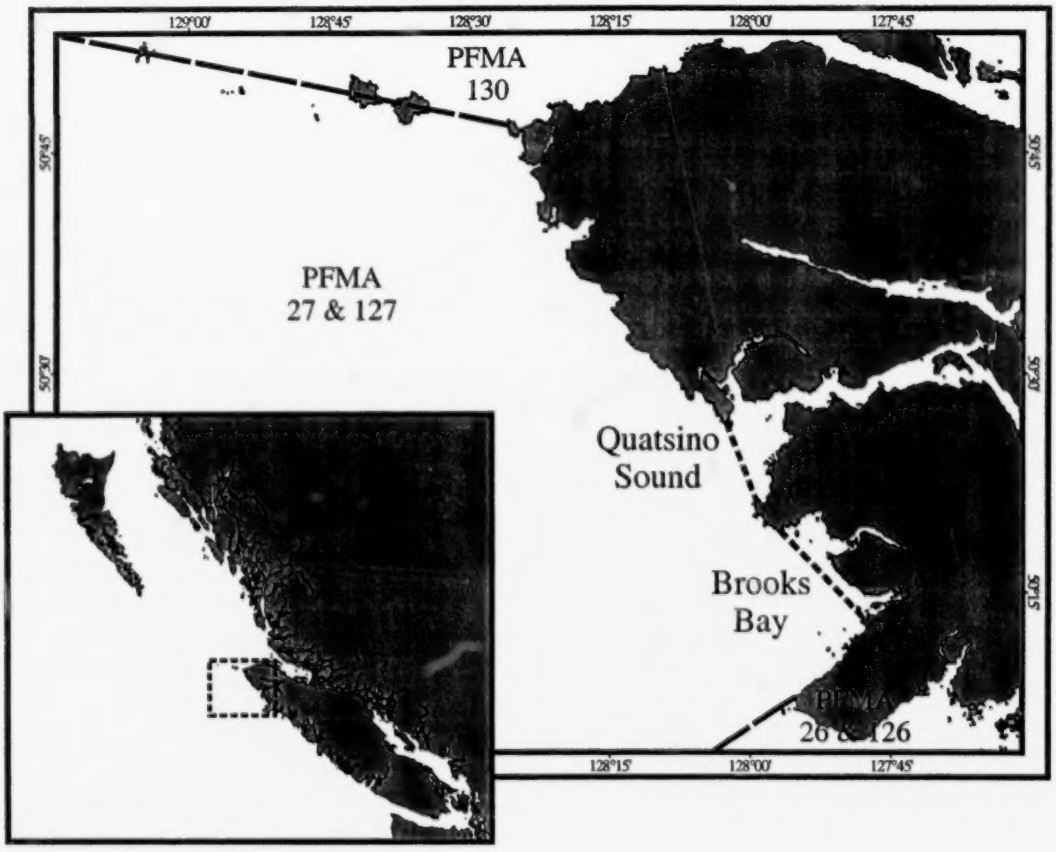

Figure 1. Map of abalone survey area, north-west coast of Vancouver Island.

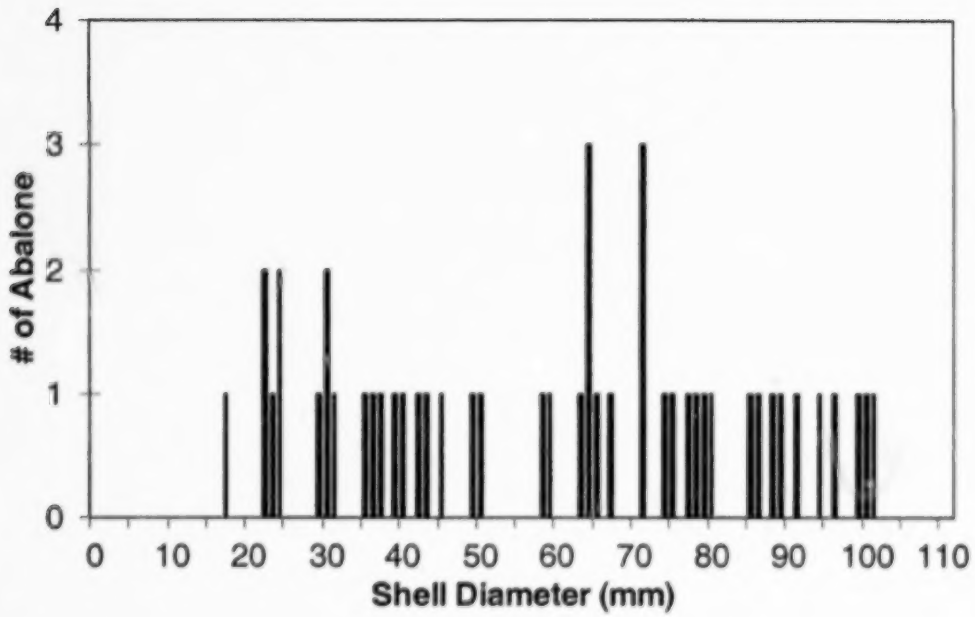

Figure 2. Size frequencies of exposed abalone for all transects surveyed on the north-west coast of Vancouver Island, May 2003.

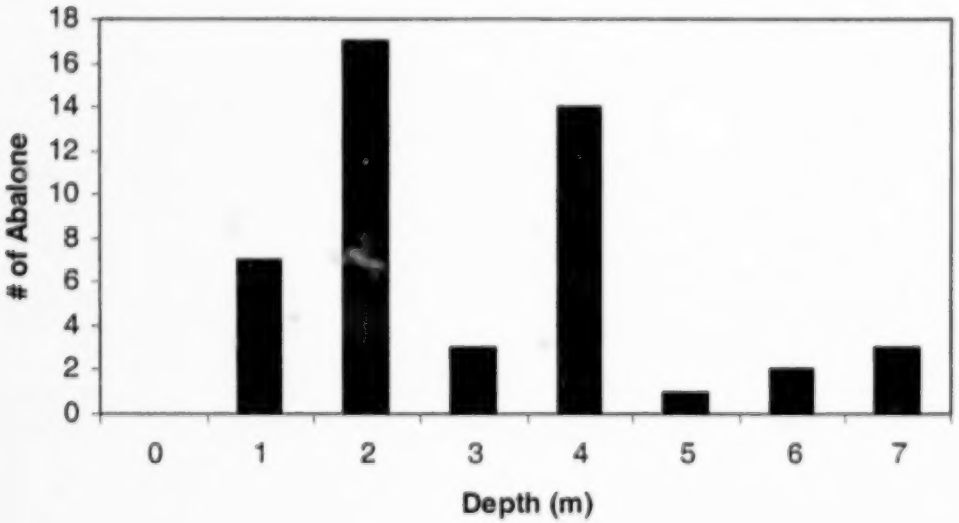

Figure 3. Abalone counts by depth for all transects surveyed on the north-west coast of Vancouver Island, May 2003.

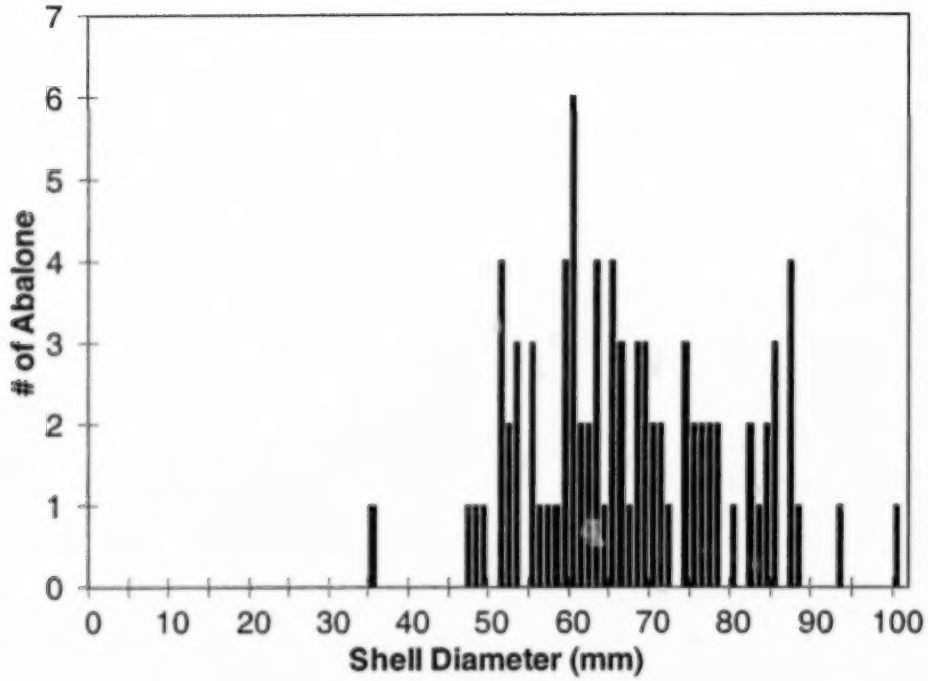

Figure 4. Size frequencies of abalone collected for DNA analysis from Quatsino Sound, north-west Vancouver Island, May 2003.